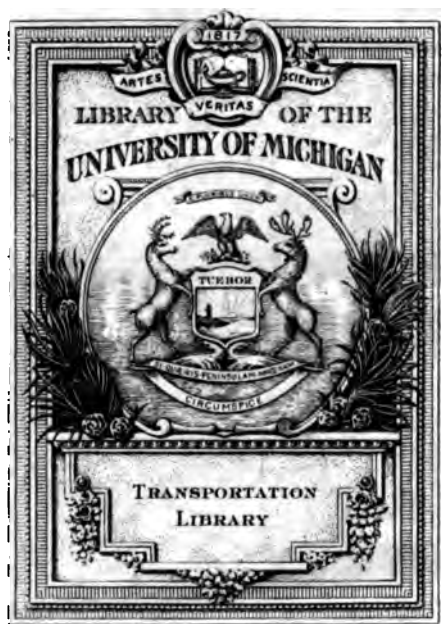
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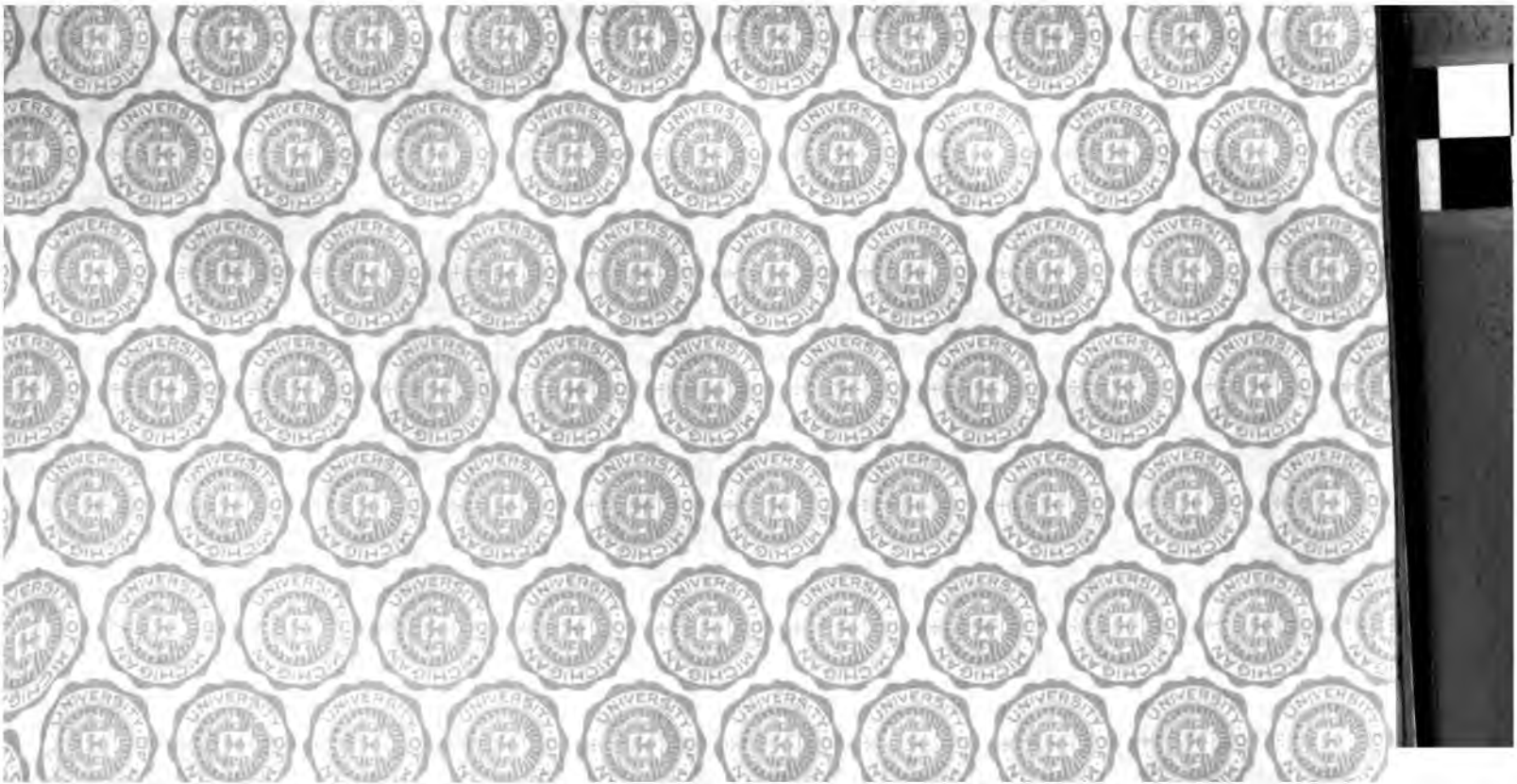
UNIVERSITY OF MICHIGAN

REMARKS

ON

CERTAIN STATEMENTS

REGARDING THE

INVENTION OF THE STEAM ENGINE,

IN

M. ARAGO'S

HISTORICAL ELOGE OF JAMES WATT.

BY HUGO REID.

Damn with faint praise, assent with civil leer,
And, without sneering, teach the rest to sneer.

Flat justitia.

GLASGOW:
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TO THE

PHILOSOPHICAL SOCIETY

OF GLASGOW;

WHOSE DESIRE

TO VINDICATE THE FAME AND DEFEND THE RIGHTS

OF THEIR COUNTRYMEN—

WHO CHIEFLY INVENTED STEAM ENGINES,

AND FIRST CONSTRUCTED THEM, AND BROUGHT

THEM INTO OPERATION—

LED TO THE PUBLICATION OF THIS ESSAY,

IT IS RESPECTFULLY INSCRIBED

BY THE AUTHOR.

PREFACE.

THE following extract from the Minutes of the Philosophical Society of Glasgow, forwarded to me by Mr. HASTIE, the Secretary, will explain the origin of the present publication.

4th December, 1839. WALTER CRUM, Esq. Vice President, in the chair.—As intimated at last meeting, Mr. HUGO REID read a paper entitled 'Remarks on the statements in ARAGO's life of WATT regarding the invention of the Steam-Engine.'—Various members having spoken, all in confirmation of the views advocated by the Essayist, it was moved by Mr. THOMAS EDINGTON, that Mr. REID be requested to publish his paper, which motion having been seconded by Mr. ROBERT MUIR, and backed by the unanimous vote of the Society, Mr. REID acceded to the request.

The Historical Eloge by M. ARAGO is the first memoir of JAMES WATT, which has appeared in a separate form, and, as such, will naturally attract some attention. It comes to the British public backed by the weight and authority of the FRENCH ACADEMY of SCIENCES, before whom it was read; and with another powerful recommendation in the deservedly high name of its Author. Though occasionally somewhat laboured and inflated, it is executed in rather a tasteful and elegant style. The leading

points, those which are really important and interesting, are selected with judgment, and explained and illustrated with clearness and effect. There is great interest felt by the public, not only in the illustrious individual who is the principal subject, but in the secondary subjects, such as the progress of the Steam-Engine, of which the memoir treats. One edition has already been issued in this country in two different forms,* and another translation is announced. From these circumstances, M. ARAGO's Eloge may acquire a weight which will cause the impression it creates to fix on the public mind. It is therefore the more necessary to examine this memoir with care and minuteness, to look at the spirit as well as the letter, and to correct any errors it may contain or tend to create, even at the expense of sometimes appearing hypercritical.

On perusing M. ARAGO's work, it appeared to me that great injustice was done to SAVERY and NEWCOMEN, the inventors of the first Steam-Engines; and that, in various ways, the fame of WATT was lessened, and his labours undervalued. Had M. ARAGO merely exaggerated the value of what was done by DE CAUS and PAPIN, it would not have been worth noticing; but as it certainly ap-

* In the Edinburgh Philosophical Journal for October, and separately, in an 8vo volume, published by Messrs. Adam and Charles Black of Edinburgh.

peared to me that SAVERY, NEWCOMEN, and WATT, on whom I had always looked as the inventors of the Steam-Engine, were coldly treated, and even depreciated in the Eloge, I deemed a correction of his errors not an unfit subject to bring before the Philosophical Society of this place, where every thing relating to WATT and the Steam-Engine is always regarded with peculiar interest. On meeting with the members in the Society Hall, before the paper was read, I found that those who had perused the Eloge were impressed with sentiments similar to my own regarding it. Upon discussing the subject, all appeared to be desirous that some criticism on M. ARAGO's statements should be brought out, which would have the prominence and publicity that a separate publication would give it.

M. ARAGO himself seems to have been aware that exceptions would be taken to some of his views. In commencing the historical notice of the invention of the Steam-Engine, he remarks :

"I approach this enquiry with the firm determination of being impartial,—with the most earnest solicitude to bestow on every improver the credit which is his due,—and with the fullest conviction, that I am a stranger to every consideration unworthy of the commission you have conferred upon me, or beneath the dignity of Science, originating in national prejudices. I declare, on the other hand, that I esteem very lightly the innumerable decisions which have already emanated from such prejudiced sources; and that I care, if possible, still less, for the bitter criticisms which undoubtedly await me, for the past is but the mirror of the future."

I trust that if any remarks offered here should appear bitter, it may be only upon the principle that, truth is sometimes the severest libel. I am conscious of the deference due to the high and well known fame of the distinguished man whose views I have ventured to criticise. But, having once undertaken the task, which has been in a manner assigned to me, I have resolved to consider the subject alone, without respect of persons; and to state fearlessly the impressions it has produced in my own mind. Should it be considered by any that a somewhat harsh construction has been put upon M. ARAGO's statements and omissions; I can only say that I have not expressed any sentiment, without giving a full view of the facts of the case, stating my reasons, and quoting the passages in the Eloge which are commented on, so that the reader has all the data to enable him to judge for himself. Having, both here and elsewhere, given a more favourable view of the share of the French (DE CAUS and PAPIN) in this great invention, and a less favourable estimate of the claims of LORD WORCESTER, than most British authors, I hope I shall not be accused of a national leaning. I have given, on data accessible to every one, and chiefly on data furnished by the Eloge itself, what appears to me to be the true state of the case. *Suum cuique tribuito* has been my guide. How far I have adhered to it, others must judge.

There is one period in the history of the development of Steam-power, which is still rather involved in obscurity—the period between the discovery of the atmospheric pressure and air-pump and the labours of PAPIN. Were the mechanical works of that period carefully examined, something might be discovered which would throw light on the development of that ingenious plan, so important in its conjunction with steam—the production of motion by producing a vacuum on one side of a piston, thereby giving effect to the pressure of the atmosphere on the other side. M. ARAGO speaks of no one but PAPIN in connection with the origin of this valuable contrivance, but, as will be shewn afterwards, OTTO GUERICKE had a considerable share in it. The ABBE HAUTEFEUILLE also, there is reason to believe, had a part in developing this idea, but I have not been able to meet with a satisfactory account of any of the plans of this ingenious mechanic. I state this with the view of suggesting the investigation to those who have the opportunity of meeting with the works of that period, particularly those of HAUTEFEUILLE.

GLASGOW, *December 10th*, 1839.

REMARKS

ON

M. ARAGO'S STATEMENTS REGARDING THE INVENTION OF THE STEAM-ENGINE.

It has always been considered a matter of some importance to ascertain who are the authors of discoveries or inventions which have forwarded the progress of Science and the Arts, and thus proved useful to Society. That mankind should ever hasten to do honour to those who have added a new truth to the general stock of knowledge, or placed some new or increased power within their reach, is of importance, as an incentive to genius, were it of no other use. It will undoubtedly be a powerful stimulus, even though it may often lurk in the breast and not be confessed or distinctly felt; and many a genius, by "chill penury repress'd," or by neglect, will find secret consolation and encouragement in the thought that posterity at least will do him justice, and take some pains to ascertain who is the real author of an useful invention, and distinguish him from those who, from various accidents, may have had an undue prominence

assigned to their labours. It is true enough that this, the desire of fame, present or posthumous, is not the highest or purest motive to excite men to extend the boundaries of Science, and enlarge the powers of Art;—but it is *a motive*, and, certainly, not a bad one; and being of undoubted service to mankind, ought surely to be respected.

The love of justice—the desire to see fair dealing between man and man—is inherent in the human mind. And, however this feeling may be blunted, and choked by the weeds of party animosity, national prejudices, or personal jealousies, during the lifetime of the candidates for fame; it should ever be carefully freed from these when we are considering the character and deeds of those who have passed from this scene, and cannot assert their own claims. Their fame and reputation ought to be held sacred; the only portion they now have in this world should not be touched with a rude hand.

But whether determining the true authors of discoveries be intrinsically important or not, it has become so. From a mixed feeling of pride, curiosity, and a sense of justice, a keen interest has always been taken in such investigations. In all ages and in all countries, distinguished men are considered to have conferred a lustre on their native place, on those spots where they have been educated, or lived and flourished. The sphere of action of those who have rendered themselves illustrious has always been honoured for their sake; and the citizens of every community have been very jealous of the reputation of those of whom they feel proud. This feeling has led to disputes, partaking somewhat of a

national character, and conducted, occasionally, with no little keenness and acrimony.

There has been a good deal of discussion between the French and ourselves, as to the invention of the Steam-Engine. There has been the more room for misunderstanding or misrepresentation on this point, that this great machine was certainly *not entirely* the production of any one mind, but of many, each working with the vantage ground of the hints or labours of those who preceded him. It is not easy to assign a numerical value to the services of each inventor, and therefore, those who glance at the subject hastily or superficially may easily be led into erroneous views. To understand the subject thoroughly, it must be gone into minutely, and studied with care.

All are agreed that to JAMES WATT, the chief honour is to be awarded of having given to the Steam-Engine the great power, and varied utility, which now distinguish it. But there are others, preceding WATT, whose claims have been the subject of contention. And even the fame and merits of WATT himself may be detracted from considerably by giving an exaggerated estimate of the value of the inventions of others; and by associating them with WATT as if on an equal footing; more especially if those who are thus elevated to the same level were on the same track of invention.

In both of these points—1. As regards the respective merits of those who paved the way for WATT, and 2. As regards the merits of WATT himself, I conceive that the Memoir of M. Arago calls for some remark.

It will smooth the way very much, in the investigation of the questions before us, to examine shortly the various modes of applying Steam as a power, and divide the invention into separate stages as much as possible. This will enable us more easily to come to a judgment on the comparative value of each step.

There are two modes of using Steam for the production of force or power. 1. *Directly*, when the force or pressure of the steam itself produces the power. 2. *Indirectly*, when the steam is used to form a vacuum, and thereby give effect to some power acting into the space where the vacuum is made.

I. DIRECT ACTION OF STEAM.

The direct force of steam has been proposed to be applied to the production of motion in *three* principal modes.

First, in point of simplicity, though not in order of chronological development, by the impetus which it has after issuing from a vessel in which water is boiled. Every one has noticed that the steam from a boiler issues with a considerable degree of force and velocity. On the principle of the windmill, this current of Steam in motion, will communicate motion to the vanes of a wheel properly adjusted to receive it, and thus turn the wheel. This very simple plan for steam power was proposed by BRANCA in 1629, and by KIRCHER some years after. From the resistance of the air, the con-

densation the steam undergoes, and the low specific gravity of steam (484, air at 60° being 1000—less than one half of the weight of an equal bulk of air), it can communicate very little impetus when applied in this manner.

Second. The pressure of confined steam. This is the next mode, in respect to obviousness, and simplicity. If water be boiled, and the steam be prevented escaping, it will accumulate, and press with great force on the bodies which confine it, pushing aside, with more or less power, those which present least resistance—and thus raising liquids in contact with it, bursting the vessel in which it is confined, or moving a piston along a cylinder—according to the mode in which it is applied.

The power of confined steam has been made use of in two principal modes: 1. To raise water, to which it is directly applied, as in the plans of PORTA, DE CAUS, SAVERY, and PAPIN'S second scheme.—2. To press a piston through a cylinder, and thus cause a rectilineal motion, which may be adapted by appropriate machinery to any purpose; as done by LEOPOLD and WATT.

Third. Steam may be employed as a source of power, on the principle of the reaction of a fluid issuing forcibly from a tube, and if projected sideways, thereby tending to push back the tube in a direction opposite to that in which the fluid issues, as in Barker's mill. If the tube be made to turn on a pivot, and a continued stream issue sideways from its extremity, the tube will be turned continuously round, and thus a rotary motion be procured. This is the principle of the first Steam machine, HERO'S

Æolipile, described 130 years B.C., and it has been revived by KEMPEL in 1794, and brought lately into operation by AVERY in America, and by RUTHVEN in this country.

II. INDIRECT ACTION OF STEAM.

Steam is condensible into water; its elastic force is thereby reduced to nearly an insensible amount, a nearly perfect *vacuum* being produced. If steam be driven into a vessel containing air, and with an aperture to permit the air, or air and steam, to pass out, the air will soon be expelled and the space filled solely with steam. This aperture being now shut, and also that by which the steam entered, and the steam being cooled, it condenses, and the external air, or any other force acting towards the vacant space, not being now resisted, yields a source of force or power which may be easily applied so as to produce motion.

Such are the modes in which Steam may be used in the production of motion.

To produce the Steam-Engines of SAVERY, NEWCOMEN, and WATT, the three which have come into use,* some one or more of the preceding general properties of steam are called into action. But besides these, there are a number of points in the mechanical adaptation of the parts, which are essential to the construction of these engines. The following statement embraces the leading conditions of every

* AVERY'S, on the principle of the Æolipile might be added. It is much employed in America.

kind, connected both with the steam and with the mechanism, necessary to the invention of these Engines, and which therefore, have a value in relation to the Steam-Engine, and entitle the discoverer to a place among those who contributed to the development of Steam-power. Upon *analyzing* the Steam-Engine, we find the following leading and distinct ideas, entering into its construction and operation

Properties of Steam.

1. That a steady and continuously acting power is procured by confining the steam issuing from boiling water.

2. That when steam is condensed, a vacuum is produced, into which the adjoining bodies will tend to rush:

3. That steam is most rapidly condensed by projecting water into it.

4. That the vapour of water has a considerable force or pressure even at temperatures much below the boiling point, as 100° to 140°.

5. That a vacuum may be produced by steam without cooling the vessel in which it is contained, if a connection be opened with it and another vessel in which a continual vacuum is kept up.

6. That if the external pressure (the compressing force) on a quantity of confined steam be less than the force of the steam, it will tend to expand and cause motion in the bodies confining it.

7. That the Steam of common water contains air which does not condense on being cooled.

Mechanical Contrivances.

That if a vacuum be produced in a cylinder below a piston, the atmospheric pressure will cause the piston to descend.

That an alternate rectilineal motion is easily transmitted to a distance by a lever (beam) working on a pivot.*

These modes of applying steam, these principles of its action, and these mechanical contrivances being kept in view, we find the following successive stages, and distinct ideas, in the development of the use of steam as a moving power;—at the side are shewn the names of the individuals who contributed each step. It is only by such an analysis that we can judge of the comparative value of the services of the successive labourers in this great work.

1. The publication of the fact that steam may be made to yield a force or power.	Hero, 130, B.C. Garay, 1543. Mathesius, 1571. Rivault, 1605.
2. The publication of the fact that steam may be made to yield a *steady continuously acting* power.†	Hero, 130, B.C. Garay, 1543. Porta, 1606. Branca, 1629.

* I have here given only those leading mechanical contrivances used in Newcomen's Engine. Those in Watt's Engine are so numerous, that they would require considerable space, and would render the subject complex: they will be alluded to separately afterwards.

† It will be at once perceived that this, a steady continuously acting property, is an essential element in the application of steam as a moving force. It includes No. 1—but is something additional. No. 1 does not include it—may exist without it; as in Rivault's Experiment, &c.

3. The publication of the fact that water may be raised by the force of steam, coming from boiling water, and confined.	PORTA, 1606.
4. The constructing and describing an apparatus by which this would be effected.*	PORTA, 1606.
5. The publication of the fact that if a space to which water has free access be filled with steam, and the steam be then condensed, the water will rush into that space.	PORTA, 1606.
6. The proposal to apply the power of steam as in Nos. 3 and 4, to use, for raising water on the large scale.†	DE CAUS, 1615.
7. The suggestion, to procure a power or force by the pressure of the air on a piston in a cylinder, a vacuum being made below the piston.	GUERICKE, 1672.

* In the invention of a machine, the construction and description of an apparatus to effect the object is of so much importance, and may be wanting while the general principle is pointed out, that Nos. 3 and 4, though by the same individual, are separated.

† The apparatus of DE CAUS, containing nothing beyond PORTA'S, is not mentioned. The idea of use on the large scale is all that is DE CAUS'.

8. The directing public attention forcibly to the application of steam for raising water, proclaiming that large masses of water had been raised great heights by steam power, with obscure hints as to the plan.* WORCESTER, 1663. MORLAND, 1683.

9. Suggesting to procure a vacuum below a piston by boiling water under it and then condensing the steam, instead of by the air-pump, the air's pressure then pushing down the piston.† PAPIN, 1690.

10. Planning, constructing, and bringing into operation an Engine, to raise water great heights, partly by the ascent of the liquid into a vacuum formed by condensing steam, and partly by the force of the steam directly applied; and requiring a great number of different parts and different principles, ingeniously adjusted. SAVERY, 1698.

11. The planning, constructing,

* Few, I suppose, will dispute, that it lends some aid to the progress of an invention, to have it confidently proclaimed that it has been done, or even that it may be done.

† Besides this, there is some reason to believe that PAPIN also raised the piston by the force of the steam coming from the the water boiling under it. I do not consider M. ARAGO's neglecting to mention it, as a proof that PAPIN has no claims to this device.

and bringing into operation an efficient engine, requiring a great number of different parts ingeniously adjusted, to work a common pump, by a BEAM, and CYLINDER with a PISTON, moved by atmospheric pressure, a vacuum being procured below the piston by condensing steam. NEWCOMEN & CAWLEY, 1705.

12. The planning, constructing, and bringing into operation a Steam Engine, embracing several important new inventions, and far more efficient and economical than Newcomen's. JAMES WATT, 1769.

13. The planning, constructing, and bringing into operation, a Steam Engine with several new inventions, and some new applications, and adapted for the great end of impelling machinery. JAMES WATT, 1784.

Such were the *hints, suggestions, discoveries, inventions*, from HERO, 130, B.C. to WATT. All that M. ARAGO mentions are in the above table, and several that he does not mention. Whether or not they are to be considered as *steps in the development of steam as a power*, the reader can easily judge. I have no hesitation in adducing every one as having aided in paving the way for this great power. It is the degree of merit which

ought to be attached to each, which forms the debateable question.

M. ARAGO leaves out of the catalogue of contributors to the Steam-Engine, all the names whom I have attached to the five first heads in the above table, as not being entitled to rank among the inventors of this great machine, excepting RIVAULT.* He commences with RIVAULT's experiment, and the proposal of DE CAUS, whose merits he greatly exaggerates. He omits Nos. 7 and 8. No. 9, the scheme of PAPIN, is praised extravagantly, and estimated far beyond its value. Nos. 10 and 11, the schemes of SAVERY and NEWCOMEN, are half suppressed, slurred over, misrepresented, and unhandsomely depreciated. And lastly, Nos. 12 and 13, the labours of James WATT, are slighted and depreciated by various remarks, and by associating PAPIN with WATT, as if on an equal footing. These assertions, and that those whom M. ARAGO has omitted ought to have a place, I now proceed to prove.

M. ARAGO rejects the scheme of HERO from all place in the list of contributions to the modern Engine. As far as regards the mode of applying the power and details of the machinery, this is correct. But it must be evident that HERO's Æolipile, so striking and distinct an exhibition of a moving power or force procured by steam, must

* GARAY, and MATHESIUS, are totally omitted, PORTA mentioned in a note, only to be rejected, and HERO discarded because he was on a different track from the mode ultimately adopted of applying steam power.

have had some effect in directing attention to the useful properties of steam; to the great truth, that a force is procurable by boiling water, and thus have aided in keeping the general idea before men's minds.

After describing the scheme of HERO, and alluding to many obscure hints as to steam power, M. ARAGO remarks—

"After these faint glimmerings of the Greek philosophers, we must pass over an interval of nearly twenty centuries, before we meet with any useful notions concerning the properties of steam." p. 30.*

Thus, "at one fell swoop," we have GARAY, MATHESIUS, and PORTA annihilated—GARAY, who, at Barcelona in 1543, propelled a vessel on the water without sails or oars "by an apparatus, of which a large kettle filled with water was a conspicuous part."—and MATHESIUS, who, in 1571, gave a hint that a powerful machine might be produced by steam, using the graphic terms, "mighty effects could be produced by the volcanic force of a little imprisoned vapour." We are not claiming much merit in contributing to the development of Steam-power, for these, as GARAY's plan was never published, and MATHESIUS did little more than give the hint of a power being procurable by imprisoning vapour, and that it might be applied to a machine. But, as it is clear that they possessed superior knowledge on the subject, and *that a knowledge of what they did or said falling on*

* Life of James Watt, by M. Arago; Edinburgh, Adam and Charles Black. This edition is referred to throughout.

a congenial soil, might, by calling attention to th subject, or even giving the hint for experiments, *b the germ of something useful*, we cannot refuse then a small niche in the temple dedicated to the origin ators of Steam-power.

GARAY was a Spaniard; MATHESIUS a German It is rather singular, that, while these are doome to oblivion, M. ARAGO does not forget to mentio "our [his] countryman GERBERT." True, he re jects him from the list (in which he has hardly eve been placed) on the grounds, that his project wa not for steam as a force or power; but he i brought forward as author of an invention con nected with Steam. It appears to me that th few lines occupied in knocking down the *man o straw*, GERBERT, would have been better spent i paying a small tribute to the *true men*, GARAY, an MATHESIUS.

Immediately following the passage quoted above M. ARAGO proceeds, p. 31.

"From that time onwards, experiments, precise, conclusive and irresistible, took the place of mere idle conjectures.

"In the year 1605, FLURENCE RIVAULT, a gentleman of th bedchamber to HENRI IV., and the preceptor of LOUIS XIII. discovered that an iron ball, or bomb, with very thick walls, an filled with water, exploded sooner or later when thrown into th fire, if *its mouth were closed*, or, in other words, if you prevente the free escape of the steam as it was generated. The power o steam was here demonstrated by a precise proof, which to a cer tain point, was susceptible of numerical appreciation."

This experiment certainly deserves a place i the history of Steam. But it is of extremely littl value in reference to the Steam-Engine. Its objec is a sudden explosive action, not that steady con

tinuous power required in a Steam-Engine. It was not connected with the action of any machine: it was not, from the violent, uncertain, dangerous nature of the effect, likely to lead others to the idea of steam being used for any steady regulated motion. RIVAULT had no idea beyond the bursting of the bomb. In itself it was of no value connected with the construction of a Steam-Engine. It can only be admitted, as perhaps setting the minds of others on a useful track, and in this respect was far inferior to what others had done. MATHESIUS' few words published more than 30 years previously, were much more likely to lead to the idea of a Steam-Engine, for he published the important truth, then new, that "imprisoned vapour" was possessed of "volcanic force," that it would produce "mighty effects," and suggests a machine for the purpose. The words of MATHESIUS were invaluable. It appears very strange, therefore, to omit the latter, and lay such stress on RIVAULT.

All that RIVAULT's experiment could do was this—give a striking illustration of the great force that might be got from Steam, to fix in people's minds the loose general idea that something might be done by steam, and thus turn the attention of others to the subject. Of all the inventors, he was farthest from any thing like a Steam-Engine, because the power he exhibited, was sudden, violent, dangerous, irregular in its action, and therefore farthest from what is wanted in the Steam-Engine. RIVAULT only shewed that water could be made to produce an effect like gunpowder. Yet this powerful agent was long known without

any attempts to get a steady, continuous power from it; from the evident reasons just stated in reference to water. Keeping in view the important consideration, that a power was wanted which should not be intermitting, and which should be easily regulated; and considering what was done by MATHESIUS previously, and by PORTA about the same time, RIVAULT seems rather out of place among the inventors of the Steam-Engine, except in a very secondary rank.

M. ARAGO then goes on to trace the connection between RIVAULT's bomb, and the apparatus of DE CAUS, and remarks, p. 32.

"For this bomb let us now substitute a strong close boiler of large dimensions, and then there is nothing to prevent our forcing great masses of liquid to indefinite heights by the sole action of steam; and we shall have constructed, in every sense of the word, a steam-engine which might serve the purpose of drainage.

"And now you have been made acquainted with that invention* for which France and England have contended, as formerly the seven cities of Greece respectively claimed the honour of being the birth-place of Homer. On the other side of the channel they have unanimously ascribed the honour to the MARQUIS of WORCESTER, of the illustrious house of SOMERSET. On this side, again, we maintain that it belongs to a humble engineer, almost forgotten by our biographers, namely, SOLOMON DE CAUS, who was born at Dieppe, or in its neighbourhood."

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* DE CAUS' Engine. This consisted of a globular boiler with two apertures, one through which water was put into the boiler, another with a tube passing tight through it open at both ends, and going to the bottom of the boiler in the interior. The boiler full of water being set on a fire, steam rose from the water, accumulated above it, and pressed it up through the tube.

Of the precise merits of DE CAUS we shall speak a little further on.

M. ARAGO then proceeds to shew, very summarily, and with a triumphant air, that as DE CAUS preceded WORCESTER by many years—"For who can maintain that the year 1615 did not precede the year 1663."—DE CAUS and not WORCESTER must be regarded as the inventor or originator of the Steam-Engine; a wondrous easy task, if the two engines were the same, and if one of them is to be regarded as the first Steam-Engine, two points which M. ARAGO assumes without any discussion or reason given.

But they were not the same, for in WORCESTER'S Engine there is reason to believe that there was a vessel for generating the steam, distinct from that containing the water to be raised—a most important difference, as we shall see on speaking of SAVERY'S Engine. And, we shall find presently, that neither DE CAUS nor WORCESTER has claims to a place of any consideration among the contributors to the STEAM-ENGINE.

M. ARAGO speaks of writers on this side of the channel, as "those whose principal aim seems to have been to remove every French name from this important chapter in the history of Science." This may be believed in France, where British histories of the Steam-Engine are not much known, and there create a prejudice against British writers as having suppressed the claims of DE CAUS and others. But it so happens, that almost every British author has not only mentioned DE CAUS, but given the whole of what that Engineer has left on the subject of

steam-power, including the drawing of his machine. They may differ among each other, and with M. ARAGO as to the value of his services. But they have placed the full data before their readers. See FAREY, LARDNER, STUART'S work, dated 1829, &c. M. ARAGO seems well acquainted with MR. STUART'S work. In another of this writer's works, of which the Third edition is dated 1825, DE CAUS is fully brought forward.

M. ARAGO states, "It is exceedingly doubtful whether either SOLOMON DE CAUS or WORCESTER ever constructed the apparatus they proposed."—It is almost absolutely certain, from various passages in the writings of WORCESTER, from some of his acts and those of his widow, from the report of a foreigner, who saw it, and from some acts of Parliament, that WORCESTER did construct, exhibit to several individuals, and prove the power of his engine—and that he really had raised large masses of water great heights by it.—And it is certain that the report of what WORCESTER had done, along with a vague idea of the manner in which he effected it, aided in no small degree in stimulating others to successful attempts to raise water by steam. M. ARAGO, if he doubts that WORCESTER constructed a machine for raising water by steam, should have, at least, mentioned that there are many who believe WORCESTER to have constructed an efficient engine. He might have found strong reasons given for this opinion, in the work of MR. ROBERT STUART. WORCESTER possessed one point characteristic of an inventor, in which DE CAUS was deficient. He was aware of and proclaimed the peculiar value

of his invention—brought it out prominently as something great—and by his confidence in its success, must have inspired others with an idea favorable to the application of steam power. Whereas, DE CAUS mentioned his scheme for raising water by steam only as a thing that might be, among a number of other plans, of which many were useless, and had far more importance assigned to them than the steam scheme.

But the truth is, that neither WORCESTER nor DE CAUS are entitled to the high place that has been assigned to them among those whose hints, or inventions, aided in introducing the use of steam as a source of power.*

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* LORD WORCESTER was evidently a man of considerable mechanical genius and knowledge; and, had he done more and talked (or boasted) less—had he explained clearly, and published any of his numerous schemes—he might have assisted, in no small degree, in forwarding the invention of many ingenious machines, now come into use. But, instead of instructing mankind how to carry any one of his numerous schemes into effect, he contented himself with the glory of blazing forth a catalogue of what he could do.

The claims of the MARQUIS OF WORCESTER to be considered the inventor of the Steam-Engine, have been the subject of much discussion. It is clear, from the description, that he had the idea of the elastic force of steam, pressing water upwards in a tube, as DE CAUS and PORTA had; indeed, it is most probable that he derived his knowledge from the work of DE CAUS, which was published at Paris in 1623. There is every reason to believe that he had used a separate vessel for forming the steam from that which contained the water to be raised, as PORTA and KIRCHER had. The separate boiler was a most important addition to DE CAUS' plan. Moreover, he constructed an engine, and proclaimed its applicability, as a moving power, to a variety of purposes. But his description

"And now let us examine particularly the value of De Caus' labours.

In the passage quoted above, M. Arago says, speaking of the bomb, transformed into De Caus' engine,

"We shall have constructed, in every sense of the word, a Steam-Engine, which might serve the purpose of draining."—p. 32.

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is so meagre and obscure that it is doubtful if it were intelligible to others at that time; or if any one could have constructed an engine from his book. It is extremely probable that Papin, who spent a long time in England, had seen the "Century;" and, although that philosopher had much precise knowledge of the nature of steam, was the inventor of the Digester, and was labouring to introduce steam in an engine for raising water; yet he seems never to have entered on the track which the "Century" must have pointed out *very clearly, if understood at all.* Worcester never exhibited his engine to any public body; never gave an intelligible account of it. It is not clear, from the notice in the "Century" whether he meant two forcing vessels and one boiler (as is generally supposed;) two boilers and one forcing vessel; one boiler and one forcing vessel; or two vessels with fire applied alternately to each; and it is certain that no engine adapted to his description, on the most favourable construction, could ever have come into general use—the quantity of fuel consumed would have been so great. Indeed, the only part of Savery's engine (which embraces Worcester's) which has turned out workable, is that in which the water is raised by the atmospheric pressure—a plan which Worcester does not seem to have been aware of. In proposing the application, he made a step in advance of Porta; the separate boiler was a step in advance of De Caus. But as he kept his plan secret, did not develop the principle, did not give directions for applying it, far less taught mankind how to work it, he can have no claim to be considered the inventor of the Steam-Engine. All we can say of him is, that, most probably, *he knew* an improved form of De Caus' plan for raising water.

And again, in summing up the merits of DE CAUS, p, 34.

"For my own part, I cannot allow that that individual accomplished nothing which was useful, who, pondering upon the enormous power of steam, raised to a high temperature, was the first to perceive that it might serve to elevate great masses of water to all imaginable heights. I cannot admit that no gratitude is due to that engineer who was the first also to describe a machine capable of realising such effects. It ought never to be forgotten, that we can only then correctly judge of an invention, when we transport ourselves in thought to the times when it was proposed, and when we banish from our minds all the knowledge which has been accumulated posterior to its date. Let us suppose some ancient mechanist, ARCHIMEDES for example, consulted upon the means of elevating water in a vast close metallic receiver. He would have suggested great levers, pulleys, simple and compound, the windlass, and probably his ingenious screw; but what would have been his surprise, if, for the solution of the problem, some one had contented himself with a faggot and a match. Who then can refuse the title of an invention to a contrivance at which the immortal author of the primary and true principles of statics and hydrostatics, would have been astonished? This apparatus of SOLOMON DE CAUS, this close metallic vessel, in which is produced a moving power almost indefinite, by means simply of a faggot and match, will always maintain a distinguished place in the history of the Steam-Engine."

It is true that DE CAUS seems to have been the first to PROPOSE the application of steam to raise water on the large scale.

It is true that DE CAUS described an apparatus, by which, water put into the apparatus might, by the power of heat, be raised *a little* above it.

1. But it is a mistake to adduce DE CAUS as the first to perceive that steam could be made to raise water, or as the first who described a machine

which would raise water by steam: or, to represent him as perceiving that steam would raise water by "pondering upon its enormous power."

2. It is a very great mistake to represent the apparatus of DE CAUS as a steam engine which could, in any sense of the word, "serve the purpose of draining;" as a machine capable of realising such effects as "elevating great masses of water to all imaginable heights."

3. Lastly, it is a very great exaggeration of DE CAUS' idea to speak of it as an INVENTION.

These three heads we shall now discuss separately.

1. DE CAUS was not the first to perceive that steam could be made to raise water, for, nine years previously (in a work with which there is every reason to believe DE CAUS was acquainted,*) BAPTISTA PORTA had shown that imprisoned steam would raise water. DE CAUS was not the first who described a machine that would raise water by steam, for PORTA had given a description and drawing of a small machine which would effect this purpose, which was on the very same principle as that of DE CAUS', only on a much better plan. And, DE CAUS did not perceive this application of steam by "pondering upon its enormous power,"

* Though this is mentioned, it is of little import. We can never tell how far each knew of the labours of his predecessors, and in all the histories of the Steam-Engine, it is taken for granted that each knew what had been published on the subject previously.

as if he had merely known that it possessed power or force, *such as* RIVAULT'S *experiment would show*, and had applied that limited knowledge to the invention of a mode of raising water, by *adding* something, or *varying* the circumstances. Far from it. No pondering, no inventing was needed. He had only to look at PORTA'S book, where he would see the application, and mode of doing it, and a drawing with a detailed description of the experiment.

M. ARAGO rejects PORTA altogether from the catalogue of contributors to the steam engine. He says, p. 35,

"The learned Neapolitan *did not speak either directly or indirectly of any machine*, in the passage alluded to; that his object—his only object—was to determine experimentally the relative volumes of water and steam: that in the small apparatus he employed for this purpose, the steam could not elevate the liquid, according to the author's own account, above a few inches; and that in the whole description of the experiment, there is not a single word that conveys the idea that PORTA was aware of the power of this agent, or of the possibility of applying it to the production of a useful working machine."

I am not aware that it has ever been alleged that PORTA spoke of a machine—of applying the power to the production of a useful working machine. But he was most assuredly *aware of the power*. His apparatus consisted of a vessel like DE CAUS'; but instead of forming the steam from the water to be elevated, as DE CAUS did, he formed it in a separate vessel, and introduced it by a tube passing through the bottom into the upper part of the vessel from which the water was to be raised. He says, "the water melting into air will press the

water in the case, and this will force the water to rise in the canal [tube] and run out." It is but an indifferent reason for rejecting PORTA, that the steam could not elevate the liquid above a few inches in his experiment.* It does not matter, so far as the mere principle is concerned, and that is all we claim for PORTA, whether the principle was exhibited for a few inches only or for many yards —if it was clearly shown. All that we claim for PORTA was that he furnished the materials which others applied to practice. But the hint was so clear, the plan so distinctly shewn by the description and drawing, and the principle so important in reference to the use of steam as a power, that PORTA must ever occupy an important place among those who aided in the progress of this great invention.†

It is clear that what PORTA did detracts from the merits of those who followed on the same track, reducing DE CAUS to the humble office of suggesting to do with larger apparatus and larger quantities of materials what had already been done on the small scale—from an inventor to a copyist. Hence,

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* DE CAUS' apparatus would not elevate the water above one or two feet. His force pipe terminated a little above the vessel containing the water to be raised.

† MR. ROBERT STUART, in his very instructive and entertaining work, "Historical and Descriptive Anecdotes of Steam-Engines," remarks of PORTA,—"The author, it is admitted, made no application of his apparatus as a mode of raising water directly by the force of steam, from rivers and fountains; but his *diagram* and description are so complete, that its application to this purpose by another, could not be considered even as a variation of his idea."

there is some advantage to DE CAUS by throwing PORTA into the shade.

But I believe very few will concur with M. ARAGO in omitting, when tracing the progress of Steam-power, the individual who first made known, whether in an apparatus for the pocket, or in a colossal boiler, whether he proposed to apply it to practice or not, the property which first led to the useful application of steam. And BAPTISTA PORTA was the first who showed that imprisoned steam would raise water. M. ARAGO himself gives an instance of the correctness of this view. He remarks of HERO's Æolipile, which was not suggested for practice, but merely a philosophical experiment, "Were, however, the reaction of a current of steam ever to become practically useful, it would unquestionably be right to trace the idea back as far as HERO."—Surely; and let the same principle be applied to PORTA the Neapolitan, even though it does detract something from the genius of DE CAUS the Frenchman.

2. It is a great mistake to represent the apparatus of DE CAUS as "in every sense of the word, a steam-engine which might serve the purpose of draining," as a machine capable of realizing such effects as "elevating great masses of water to all imaginable heights."

These statements regarding DE CAUS' apparatus require great qualification, particularly the former. The machine of DE CAUS was no more capable of realising any useful end than PORTA's. It was only fit for a toy, or for an experimental illustration.

We are not to consider it as an useful machine, because De Caus loosely spoke of it as such.*

How could a machine serve the purpose of drainage which needed the water to be put into it by manual labour; which, from the application of the heat directly to the water to be raised, rendered it necessary that only a small apparatus and a small quantity of water could be used at a time. De Caus' plan was worth nothing without the separate vessel for generating the steam. And even when this was added, and the machine perfected by many experiments and contrivances, it was found unfit for drainage. The raising water by the direct application of steam only, has not succeeded. And the only part of the Engine of Savery, who followed on that track, capable of economical application, is that in which the water is raised by the atmospheric pressure, the steam being employed as a means of procuring a vacuum.

3. Lastly, it is a very great exaggeration of De Caus' idea to term it an invention.

De Caus did not *invent*, did not *add*, *vary*, or *adapt*. No *new power*, no *new combination* came from him. The machine even upon the plan he described, was not workable from the want of the separate Steam-generator. And without combination with another principle (water rushing into a

* Most probably, could De Caus explain his views to us, he *would complain of being represented as describing a machine*, when he only intended to exhibit the general idea and illustrate the power. The slight and loose way in which it is adduced, confirms this idea.

vacuum procured by condensing steam) it could never be applied to use.

The reader can now judge whether or not it is great exaggeration, and detracts from the merits of those who followed, to speak of DE CAUS' illustrative apparatus as a "Steam-Engine," as one which in every sense of the word might serve the purpose of drainage, as capable of useful application, as fit to elevate "great masses of water to all imaginable heights"—as "an invention, at which the immortal author of the primary and true principles of statics and hydrostatics would have been astonished." ARCHIMEDES would have been indeed astonished that it should have been termed an invention at all —that so inefficient an apparatus should have been proposed by one who had before him the far superior model which PORTA furnished.

But we hardly do justice to DE CAUS in supposing that he intended what the indiscreet zeal of some of his countrymen have claimed for him—the invention of a machine for raising water. He merely suggested the use on the large scale of a machine previously described, and gave an *illustration* of its power.

PORTA'S experiment and drawing, then, pointed out the principle and method of applying it. DE CAUS proclaimed, *this may be made useful.* We attach no value whatever to his drawing or machine. The suggestion of the application on the large scale, is all that we owe to DE CAUS. That was certainly an important step. But PORTA ought not to be forgotten. DE CAUS is not to be considered the inventor of a machine capable of giving

effect to his suggestion, thereby exaggerating l merits and detracting from those of SAVERY, w followed, and worked out the idea into a practical form. DE CAUS was no inventor, so far as t Steam-Engine was concerned. SAVERY was t first to go beyond the bare idea, to construct serviceable Engine. He did so by inventing so things new, by combining ingeniously together a new way, a number of beautiful contrivances, knowing the value of his plan, having confidence it, labouring long to perfect it, publicly advertisi and proclaiming it as something new and importa by instructing men how to form it, and bringing into operation. *Some* qualities of that kind a necessary to constitute an inventor.

We now come to SAVERY, the next in order DE CAUS, upon the plan of raising water by ste directly applied. Of this highly ingenious a successful inventor of the first Steam-Engine, ARAGO speaks as follows, p. 35.

"It is exceedingly doubtful whether either SOLOMON l CAUS or WORCESTER ever constructed the apparatus they p posed. This honour belongs to an Englishman, to Capt SAVERY. I have no hesitation in associating the machine whi this engineer constructed in the year 1698, with those of l two predecessors, although it must be added he introduc some important modifications; and among others, that of gen ating the steam in a separate vessel. If it signify little as principle, whether the motive steam be produced from the wa which is to be raised, and in the interior of the same boil in which it is about to act, or, whether it be produced in a d tinct vessel, whence it is at will to be conveyed by means of communicating pipe and a stop-cock, to the surface of the liqu proposed to be raised, it is very different in a practical point view. Another and a still more important change introduc

y Captain SAVERY, will more appropriately find a place in the marks we shall presently devote to the labours of PAPIN and NEWCOMEN.*

"SAVERY entitled his work *the Miner's Friend;* but the iners seemed scarcely to appreciate the important compliment he aid them. With one solitary exception, none of them ordered is machines. They have only been employed in distributing ater over the different parts of the palaces, of country houses, arks, and gardens, and they have not been used to raise water o a higher level than ten or fifteen yards. It ought also to be bserved, that the danger of explosion would have been great, f the immense power had been employed, which their inventor ntended might be realized.

"Although the practical success of SAVERY was so far from eing satisfactory, yet the name of this engineer should ever old a distinguished place in the history of the Steam-Engine."

This is all that is said of the *first Steam-Engine,* hat is, of the first machine which was introduced nto practice—the first which went beyond the uggestion, or illustration of the power—one which mbraced new inventions and new combinations, nd a *number* of complicated parts ingeniously djusted—which was, in every respect, at an immense distance from any thing done previously—nd which is still in use, and that, too, chiefly in M. ARAGO's own country.

I shall shortly describe SAVERY's Steam-Engine.

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* This still more important change introduced by Captain AVERY is not described in any other place, as promised above. t probably refers to the raising the water in the first instance y the atmospheric pressure acting into a vacuum procured by ondensing steam: and if it be this, it is to be remarked that AVERY is not indebted to any one for it—except in so far as he general truth, that a vacuum is procured by condensing team, is concerned.

I am sorry that M. ARAGO has not furnished a description of this Engine; had he done so, I would have quoted it.

SAVERY'S Engine was double, each part alternately performing the same function. The description of one part alone will therefore suffice. It consisted of a large oval copper vessel with two openings, one above to admit the steam; the other below to admit and then let out the water. The tube connected with the lower aperture branched into two—one proceeding downwards to the water to be raised (suction pipe); the other upwards to the point to which it was desired to raise the water (force pipe). These ascending and descending tubes, near the point where they diverged, were provided with *valves*, which opened upwards, and prevented the return downwards of any water which had passed through them. The aperture at the upper part was connected with a tube from a steam-boiler, on which there was a stop-cock, by which steam could be supplied or cut off at pleasure. Above the oval vessel there was a cistern with a rose jet, from which a shower of cold water could be made to fall on the copper vessel, and thus cool and condense any steam within.

To work the engine, steam was driven into the oval vessel: it expelled the air. The communication with the boiler was then shut (the steam cut off), and then the shower was allowed to fall upon the outside, which condensed the steam, and produced a partial vacuum in the oval vessel. Into this vacuum the water was propelled through the lower tube by the atmospheric pressure. Thus, two great objects were served. 1st, the water to be elevated *was got easily (drawn) into the vessel from which it was to be raised:* and 2nd, it was raised about 26 or 27 feet. The water being thus introduced into the vessel, from which it could not *descend*, owing to the construction of the valve in the lower tube; steam was again admitted from the boiler, which pressed upon the water, and forced it out of the oval vessel, into the upper tube, the only course it could take. Thus, by the force of the steam, it was raised as much further as was desired. SAVERY proposed to raise it 64 feet by the latter mode, making 90 feet in all.

As already mentioned, SAVERY's engine was double—there being two copper vessels, steam being admitted alternately into each to press *up* water, while a vacuum was made alternately in each by condensing the steam which had driven up the water, one vessel being filling with water rising into it by the atmospheric pressure, while the other was being emptied of water by the steam entering from the boiler.

Thus SAVERY's machine embraced the important addition of a separate boiler or Steam-generator, without which, any apparatus could only be looked upon as an *illustration* of the power of Steam. And this was something more than a mere practical detail; for, by having a separate boiler, a small quantity of water heated, sufficed to raise a large quantity, whereas, when the heat is applied to the water itself to be raised, the whole mass has to be raised in temperature to the boiling point; which would limit the power very much, independent of its inconvenience.

Also, SAVERY's machine embraced the absolutely essential contrivance by which the water was got into the vessel from which it was to be driven upwards by the force of steam. It is very easy to force the water upwards from a close vessel by steam, as DE CAUS and PORTA had shown—*but how was the water from the river, pond, or mine, to be got into the close vessel* where the steam-power was to act. SAVERY resolved this grand difficulty, by using the atmospheric pressure to force the water (by simply having a tube from the forcing vessel dipping in it), into a vacuum produced by condensing steam; and at the same time raised the water 26 feet. *This was new, as applied in that manner;* —and the combination of the two was one of

those happy thoughts which shew high inventive genius.

SAVERY'S Engine embraced the beautiful adjustments of boiler, and double steam-vessels, condensing apparatus, and valves to adapt the suction pipe and force pipe to each other. The number of parts, their simple and happy adjustment, rendered it a perfect and very beautiful machine; capable of the ends for which its inventor designed it; fit for important practical purposes; not becoming *so extensively useful* as he designed it, only from the secondary consideration of the cost of working it; and not coming into general use, because a better plan was shortly discovered (NEWCOMEN'S); *but still occasionally used.*

The reader can now judge of the extent to which, in letter and in spirit, M. ARAGO has, in the case of SAVERY, displayed an "earnest solicitude to bestow on every improver the credit which is his due."

In the *first* place, the author of this novel, ingenious, *effective*, and very beautiful invention, is most unfairly described as merely constructing the apparatus shewn in the crude project of DE CAUS. See beginning of extract p. 40. I well recollect, in studying for the first time the history of the Steam-Engine, how much I was struck with Savery's elegant engine, and delighted to arrive at last at something tangible, something shewing inventive genius, consciousness of the value of the new power, fertility of resources in combining and adding so as to make it a working machine—in alighting at last on A STEAM-ENGINE, after the obscure hints of his predecessors, the mere suggestion of DE

CAUS, and the vain boastings of WORCESTER. I believe a like feeling will arise in every unprejudiced mind on becoming acquainted with the beautiful, and masterly, and effective engine of SAVERY: and I trust that there are very few who know the facts of the case, who would represent this very ingenious mechanician, *as merely constructing* the crude machine hinted at by DE CAUS.

Secondly, We are told that the first steam-engine ever constructed, and still used, was *only* employed to raise water for gardens, and *not above ten or fifteen* yards, and that it was very liable to explosion, "if the immense power had been employed which their inventor contended might be reached." Cold praise this, for the first realisation of what it had taken centuries of hints, suggestions, and experiments, to bring into operation. I believe most persons will be disposed to laugh at the very ludicrous effect of the *only* and *not above* 30 or 45 feet, as applied to the first engine that ever did any thing at all;—when we should have expected some enthusiasm, some expression of admiration, from one who is writing the history of an invention—when, instead of pointing out *how little*, we should have expected the historian to have dwelt with pleasure on *how much* SAVERY did—when instead of being told that there would be risk of explosion if *all* the inventor had anticipated had been done—we would have naturally thought on how much could be, and is done, by using the steam only as a means of making a vacuum, without the slightest risk of explosion,

The awarding praise in general terms to SAVERY

is of little value, when the contributions of others are specially described and honoured; and what *he* did is slurred over, or omitted, or depreciated, or "damned with faint praise." The reader of M. ARAGO's sketch of SAVERY's engine, will learn little more of SAVERY, than that he constructed the machine which DE CAUS planned, and that it was a failure; and will rise with a poor idea of SAVERY's inventive genius, with nothing definite on his mind whereby to remember SAVERY, or give a foundation for the "distinguished place" M. ARAGO pretends to assign to him in the history of the steam-engine. I cannot avoid coming, then, to the conclusion, that the impression of SAVERY conveyed by M. ARAGO's statements is unfavorable, that it is far below his merits, and therefore unjust, and that it is founded on omission and misrepresentation.

After thus summarily disposing of SAVERY, M. ARAGO comes to PAPIN, his chief favourite, to establish whose supremacy, SAVERY and NEWCOMEN are deposed, and WATT robbed of half his glory.

In p. 37, M. ARAGO observes,

"Hitherto we have spoken only of machines whose resemblance to the steam-engines of the present day may be more or less disputed. Now, however, we come to the consideration of the *modern steam-engine*, which peforms so important a part in our manufactories and steam-vessels, and is essential in almost every pit and mine. We shall see it commence, enlarge, and develop itself, at one time under the inspiration of some celebrated genius, and at another, under the mere spur of necessity; for 'necessity is the mother of invention.'

"The first name which we encounter in this new period, is that of DENIS PAPIN. It is to PAPIN that France owes the honourable rank she may claim in the history of the steam-engine."

PAPIN'S contrivance we shall describe in M. ARAGO'S own words, p. 38,

"Conceive a wide vertical cylinder open above, and reposing at its base upon a metal table pierced with a hole which a stopcock can at will shut and open. Let us now introduce into this cylinder a piston, that is to say a large and moveable circular plate, which accurately fits it. The atmosphere will press with all its weight upon the upper side of this kind of diaphragm, and will tend to push it from above downwards. That part of the atmosphere again which fills the lower part of the cylinder, will tend, by its reaction, to produce the inverse movement. This second force will be equal to the former if the stopcock be open, for gases press equally in all directions. The piston will thus find itself operated on by two opposing forces, which will produce an equilibrium. It will nevertheless descend, but only in virtue of its own gravity. A slight counterpoise somewhat heavier than the piston, will suffice to draw it contrariwise to the top of the cylinder, and to keep it there. Suppose the piston arrived at this point, we have now to seek for the means of making it *forcibly descend*, and then ascend again.

"Suppose that, after having shut the lower stopcock, we should succeed in annihilating *suddenly* all the air contained in the cylinder,—in a word, in making a vacuum; the piston receiving only the action of the external air, pressing from above, would *rapidly descend*. This movement accomplished, we might then open the stopcock, the air would then enter from beneath, and would counterbalance the pressure of the atmosphere above the piston. As at the commencement, the counterpoise would now raise the piston to the top of the cylinder, and every portion of the apparatus would be found in its original state. A second evacuation, or we may call it abstraction of the internal air, would make the piston again descend, and so on successively. The true moving power of this machine would here be the weight of the atmosphere. And let no one suppose that because we walk and even run with facility through the air, the atmosphere must therefore be very feeble as a moving power. With a cylinder of two yards in diameter the pressure of the piston in descending—the weight it might raise throughout the whole height of the cylinder at each stroke, would be about 600 cwt.

This enormous power, frequently repeated, may be obtained by means of a very simple apparatus, provided we could discover a method, at once prompt and economical, whereby we might produce and destroy at pleasure an atmospheric pressure in a metallic cylinder.

"This problem Papin resolved. His beautiful and grand solution consists in the substitution of an atmosphere of steam for the common atmosphere,—in the replacement of this latter by a vapour which, at 212°, has precisely the same elastic force, but with this important advantage, of which the common atmosphere is destitute, viz., that the power of aqueous vapour is enfeebled very rapidly when the temperature is lowered and that it almost wholly disappears, if the refrigeration be carried sufficiently far. I shall, therefore, adequately characterize the discovery of Papin, and in a few words, by saying, that he proposed to make a vacuum in large spaces by means of steam, and that his method is at once prompt and economical.*

"The machine in which our illustrious countryman was thus the first to combine the elastic force of steam with the property which steam possesses of being annihilated by cold, he never executed on a large scale. His experiments were always made on mere models. The water which was intended to produce the steam did not even occupy a distinct vessel: enclosed in the cylinder, it reposed upon the metallic plate which closed it beneath. This plate Papin heated directly, to transform the water into steam; and it was from the same plate he removed the fire when he wished to effect the condensation. Such a process, barely tolerable when experiment is intended to verify the accuracy of a principle, would evidently be altogether inadmissible, were the piston required to move with any degree of velocity. Papin remarked, that the end might be obtained 'by different constructions which might readily be conceived,' but left the constructions entirely unexplained. He devolved upon his successors both the merit of applying his pregnant conception, and that of discovering those details which alone can ensure the success of a machine.

PAPIN was undoubtedly a man of very considerable ingenuity. He invented the digester, in which, by confining the vapour, liquids may be raised to a

higher temperature than they reach when heated in the open air. He invented the safety-valve, to prevent the steam in a close vessel acquiring force above any desired point. He invented the four-way cock; and, without doubt he contributed to the invention of the modern Steam-engine; but very far from the extent which the preceding statement would imply; nor is he entitled to be considered *sole inventor* of those contrivances which he suggested.

PAPIN can only be regarded as the first in the history of the modern Steam-engine, inasmuch as he proposed to COMBINE the plan of procuring power from the atmospheric pressure by making a vacuum below a piston—with the plan of procuring that vacuum by the condensation of steam. The above quotation would almost indicate that he invented these contrivances. But this is very far from being the case. It should be known that OTTO GUERICKE, the inventor of the air-pump, had devised the contrivance of producing an active power from the atmospheric pressure, to be applied to useful purposes, by making a vacuum below a piston in a cylinder; producing the vacuum, however, by the laborious efforts of an air-pump—and that PORTA, if not many others, had shown that a vacuum was produced by condensing steam. Of these, M. ARAGO says nothing, leaving us to suppose that these contrivances had been *invented* as well as *combined* by PAPIN.

The idea of combining them was truly a happy thought, to whomsoever it belonged,* and PAPIN,

* As already hinted in the Preface, there is reason to suppose that HAUTEFEUILLE had some share in this.

so far as we know at present, seems to have been the first who did so fully. But I think it will appear very evident that his services have been overrated and his merits exaggerated by M. ARAGO, when we attend somewhat more particularly to what PAPIN really did, and what was left undone by him.

PAPIN, then, suggested that a machine might be constructed in which the piston in a cylinder would be depressed by atmospheric pressure, a vacuum having been made below it by condensing steam. He had not the idea of a separate vessel for generating the steam, from which, owing to the alternate removal and application of heat, his machine was rendered perfectly useless. He condensed the steam by means of the slow action of the cool air outside of the cylinder, which alone would prevent his engine ever being of any value. He had no beam or convenient mode of transmitting the power procured by the descent of the piston. And not only did he not succeed in his project,—*he condemned his own scheme, by totally abandoning it, and labouring at an entirely different mode of applying steam power* to accomplish the same end, raising water.

Such being the facts of the case, it is rather startling to be told, as in a passage to be quoted more fully immediately, that PAPIN "consecrated his life" to the above scheme, or, in the passage already quoted, that "PAPIN remarked that the end might be obtained 'by different constructions which might readily be conceived,' but left the constructions entirely unexplained. He devolved upon his successors both the merit of applying his pregnant conception, and that of discovering those de-

tails which alone can ensure the success of a machine"—as if he merely suspended the prosecution of his scheme from want of leisure, being still confident of its success, and imparting that confidence to others. M. ARAGO could not but be aware that PAPIN, instead of labouring at his project with that steadiness, and perseverance, and hope, which a real knowledge of its value, and a firm conviction of its being the true scheme would inspire, and transmitting it to others with the weight and sanction of his name, all of which the expression "consecrated his life" implies—completely abandoned it; and that so far as it was handed down to others, it came with the condemnation of its inventor. This little circumstance, which M. ARAGO does not mention, has the effect of impressing us with a higher opinion of the genius of those who followed PAPIN, perceived the value of his project, and worked it out. But these, NEWCOMEN and CAWLEY, of whom we shall say more immediately, have not had the fortune to fall into the good graces of M. ARAGO.

All these circumstances, of which no mention is made in the Eloge, detract somewhat from the genius of PAPIN, so far as is connected with the steam-engine, lessen the value of what he contributed to aid his successors in the invention of this great machine, and give altogether a somewhat different view of PAPIN's services from that conveyed by the imposing manner in which he is spoken of by M. ARAGO. There is some little difference, in regard to the value of a project, which is only useful as a hint to others, between consecrating one's life to it, and trying it for a little and then throwing it

aside entirely, for some other means of obtaining the same end. No disrespect to PAPIN is meant. He was undoubtedly a man of considerable mechanical genius; and of great service in forwarding the progress of steam-power. But he should not be elevated to too high a level, especially when others must be sacrificed to raise him thus to a place which is not his due.

We shall have to recur to PAPIN in reference to WATT. Let us now pass, as M. ARAGO does, to the famous atmospheric engine, the work of NEWCOMEN, who followed SAVERY and PAPIN. And here we have to complain of very great injustice to the real inventors of the first of what M. ARAGO calls *modern steam-engines.*

M. ARAGO's description of the engine of NEWCOMEN is very brief; we shall quote it.

"In the year 1705, fifteen years after the publication of PAPIN's first memoir in the Acts of Leipsic, NEWCOMEN and CAWLEY, the one an ironmonger, and the other a glazier in Dartmouth, Devonshire, constructed (and mark, I do not say projected, which is a very different thing), I repeat, constructed a machine, which was meant to raise water from great depths, and in which there was a distinct vessel where the steam was generated. This machine, like the small model of Papin, consisted of a vertical metallic cylinder, shut at the bottom and open at the top, together with a piston, accurately fitted, and intended to traverse the whole length, both in ascending and descending. In the latter, as in the former apparatus also, when the steam was freely admitted into the lower part of the cylinder, so filling it, and counterbalancing the external atmospheric pressure, the ascending movement of the piston was effected by means of a counterpoise. Finally, in the English machine, in imitation of PAPIN'S, so soon as the piston reached the limit of its ascending stroke, the steam which had impelled it was refrigerated; a vacuum was thus produced throughout the whole space it had

traversed, and the external atmosphere immediately forced it to descend.

"To produce the necessary cooling, PAPIN, as we have already stated, did nothing more than remove the brasier which heated the bottom of his small metallic cylinder. NEWCOMEN and CAWLEY introduced a process greatly preferable in every respect. They caused a large quantity of cold water to flow freely in an annular space formed between the external wall of the cylinder of their machine, and a second cylinder, somewhat larger, with which they surrounded it. The cold communicated itself by degrees to the whole thickness of the metal, and finally reached the steam itself.

"PAPIN's machine, thus perfected in so far as regarded the method of cooling the steam, or of condensing it, excited in a high degree, the attention of mine proprietors. It was rapidly introduced into many counties in England, where it was of considerable service.

This is the whole description of the atmospheric engine, excepting some allusion to the plan of condensing the steam by an interior jet, and to the engine being made to open the stopcocks itself, the latter of which was not the invention of NEWCOMEN and CAWLEY, and need not be alluded to here.

According to the preceding statement, the only thing of consequence done by NEWCOMEN and CAWLEY, was, condensing the steam in a better mode than PAPIN—"PAPIN's machine, thus perfected in so far as it regarded the method of cooling the steam."—"They constructed (and mark, I do not say projected, which is a very different thing)." One would hardly suppose from M. ARAGO's statement that they did any thing more than cool the steam in a better way. But let us examine what NEWCOMEN and CAWLEY did.

They perceived the capabilities of PAPIN's suggestion and crude machine, after it had been

abandoned and thereby condemned by the individual who, above all others, was to be expected to know its value—its author. They persevered in labouring to render it workable, although dissuaded by Dr. HOOKE, one of the mechanical authorities of the time. There, surely, we must recognise some of the qualities of an inventor. But not a word of these circumstances is to be found in M. ARAGO's history; not a syllable of praise for NEWCOMEN and CAWLEY. They are, on the contrary, treated with a sneer, for I presume it is to them M. ARAGO alludes, when he states of the modern Engine, "We shall see it commence, enlarge, and develop itself, at one time under the inspiration of some celebrated genius, and at another, under the mere spur of necessity: for 'necessity is the mother of invention'." PAPIN and WATT are prompted by genius: NEWCOMEN and CAWLEY were the only others connected with the modern engine; but they had no merit!—the mere spur of necessity did their part!

They projected the formation of the steam in a separate boiler, and contrived ingenious methods for supplying and cutting off the steam, feeding the boiler with hot water from the cylinder, &c. They projected and adjusted a method for expelling the air in the cylinder, and that which entered with the steam. They contrived a method of keeping the piston tight, by pouring water above it, a difficult matter then. They projected a plan of supplying the very important point of an easy method of transmitting the motion from the piston, in the beam playing on a pivot. They projected a mode of cooling the steam sufficiently fast to make the

engine workable. They introduced (it is of no consequence whether it was an accidental discovery or not) the excellent method of condensing the steam by projecting cold water amongst it. They made the machine itself raise the water for the boiler and for the condensation, which involved some ingenious adjustments. They laboured assiduously for years at adjusting the proportions of the parts. They brought it into operation, and it was successful. All this they did, out of the crude project which PAPIN had abandoned. And in the face of all these circumstances, which were or ought to have been known by one who writes on the history of the Steam-engine, we are told of the authors of this complex, ingenious, elaborate, and working machine, that they only constructed, did not project it; that it was the bare idea of PAPIN "perfected in so far as it regarded the method of cooling the steam!"

When the number of parts required to make the atmospheric engine effective are considered, and the exceedingly limited means PAPIN gave to work upon, and when we bear in mind that PAPIN so totally abandoned it, we must consider those as the chief inventors who made it work, and award them far higher praise than PAPIN, who merely suggested the combination of two schemes already known, could go no farther than that bare idea, and deserted and disclaimed his offspring at the very time these individuals saw its value, and by additions, new combinations, and laborious experiments, worked the principle into a practicable shape.

It would be difficult to understand why there

seems to have been such anxiety to throw NEWCOMEN'S engine as much as possible out of view, why there is not a single expression of praise or admiration awarded to it—for NEWCOMEN might receive high praise, and PAPIN'S works be appreciated too—did we not perceive that it is desired to elevate PAPIN to a level with WATT, which can only be done by throwing into the shade the intermediate inventor, NEWCOMEN. We shall find that this determination to elevate PAPIN has led M. ARAGO to what he surely cannot have intended, namely, to depreciate the subject of his Eloge, the man whom he is especially professing to honour!

But this is not all. M. ARAGO cannot part with the atmospheric engine, so grand a project in PAPIN'S hands, who did not succeed with it, and so poor a thing in NEWCOMEN'S, who brought it into use, without an additional kick.

He remarks, p. 45, in dismissing NEWCOMEN'S engine, and introducing WATT'S inventions—

"There exist in the museums of the curious, a considerable number of machines from which industry had anticipated great things, but which the expense of working and keeping them in order has rendered little more than mere objects of curiosity. Such, in all probability, would have been the fate of NEWCOMEN'S machine, at least in those districts which were not rich in fuel, had not the labours of WATT, which I must now proceed to analyze, succeeded in conferring upon them an unlooked-for perfection.

It is difficult to restrain a somewhat violent expression of indignation at the unjust and ungenerous attempt to represent NEWCOMEN'S engine, as a curious speculation, a theoretical project, a thing to be shelved in a museum.

Industry not only anticipated, but actually received great benefits from NEWCOMEN's Engine. It was fortunately superseded at last by WATT's, a more powerful and more economical engine: but if no better had been invented, NEWCOMEN's engine would have been every where in use and of the highest value at this day. For *it was an effective engine, both as regards the mechanism and the expense of working it, and a better means of raising water than the other methods then in use.*

TREDGOLD, speaking of NEWCOMEN's contrivances, says "that they produce all the difference between an efficient and an inefficient engine." NEWCOMEN's engine was the first really efficient steam-engine—that is, the first engine which could be applied *profitably* and *safely* to the more important purposes for which such machines were required at the time of its invention. It is still occasionally ordered, for situations where fuel is cheap, the first cost being comparatively small. It is fitted with a condenser, separate from the cylinder, by which its action is much improved.

Though now superseded by WATT's, NEWCOMEN's engine ought not to be forgotten. Even had it never come into use, its value, as a great step in the progress of invention—as the raw material out of which WATT constructed his admirable engine—cannot be too highly estimated. But it was a machine of great practical utility. It came into operation about 1712, and continued to be used exclusively for nearly seventy years (till about 1778—80); and for a considerable time afterwards was much employed. In 1797, it was still so much

in use and so much esteemed, that a work was written upon it by Mr. CARR. Thus, for nearly a hundred years, it was the chief hydraulic machine; and it was a century of unusual activity—of awakening energy in arts and manufactures. When it was first introduced, many valuable mines could not be worked on account of the accumulation of water. This engine not only rendered these available, but enabled others to be deepened and new ones to be opened, which could not have been done without some powerful means of raising water, cheap, safe, and manageable; which was not known till NEWCOMEN'S engine appeared. His engine was soon applied and continued to be used with great advantage in the coal-mines of the north of England, the tin and copper mines of Cornwall, and the lead mines of Cumberland, &c. It was employed in cities for supplying the inhabitants with water; in 1752 and afterwards, it was used for raising water to drive water-wheels for mills; it was used for blowing the air into the blast-furnaces for smelting iron ore; and was soon taken advantage of on the continent for similar purposes.

When these things are borne in mind, we must admit that society is under no small obligations to the inventor of a machine which, for so long a period, was an essential agent in procuring an adequate supply of materials absolutely necessary to a world advancing rapidly in numbers and civilization: and that any one who can speak of NEWCOMEN in such depreciating terms as we have seen, has yet a good deal to learn of the history of the steam-engine, and some considerations to dismiss from

his mind before he can give "every improver the credit which is his due."

We now arrive at the last head of our complaint against M. ARAGO's History of the Steam-engine—that referring to WATT himself. The following passages contain the statements by which we conceive WATT's rights are injured and his fame lessened.

P. 14. "The principal discovery of our associate, consisted in a particular method of converting steam into water."

There is a looseness in expression here, which, taking the passage by itself, may convey a very limited view of WATT's first improvement, the separate condenser. The mode of condensing the steam was the same previously employed—viz. throwing a jet of cold water amongst it. WATT's happy thought was the idea of *causing the steam in the cylinder to rush of itself out of the cylinder*, by keeping up a constant vacuum in an adjoining vessel communicating with the cylinder. When the steam arrived at the condenser, it was turned into water in the usual method. Perhaps this was hardly worth noticing, particularly as M. ARAGO explains it more correctly afterwards, and it is certainly only accidental. But those who have a high admiration of WATT's genius may be excused in cautioning against a misapprehension which might, by any possibility, detract from the fame of this illustrious man.

It may be observed, too, that the double acting engine, and expansively acting engine, were fully as ingenious, and the former as important as the

separate condenser. But this, however, is matter of opinion.

In page 38, the following statement occurs, the closing lines of which will surprise all who know anything of WATT's inventions.

"Now, we find that it was to the production of an economical moving power, capable of effecting the unceasing and powerful strokes of the piston of a large cylinder, that PAPIN consecrated his life. The procuring afterwards from the strokes of the piston, the power requisite to turn the stones of a flour mill, the roller of a flatting mill, the paddles of a steam-boat, the spindles of a cotton mill; or to uplift the massy hammer, which, with oft repeated stroke, thunders upon the enormous masses of red-hot iron just taken from the blast-furnace; to cut with great shears thick metal bars, as easily as you divide a ribband with your scissors; these, I repeat, are problems of a very secondary order, and which would not embarrass the most common engineer."

These problems, which, it is stated, would not embarrass the most ordinary engineer, were a stumbling-block to SMEATON, long after PAPIN's idea had received all the perfection of which it was capable; and they involve WATT's happiest efforts —the invention of the double acting engine, sun and planet wheel,* and parallel motion; and the application and adjustment of the crank, governor, fly-wheel, &c.

I do not attribute to M. ARAGO any intention of depreciating WATT by the above statement. I do not suppose he can have been aware of the circumstances—that WATT's latest and finest inventions

* Watt proposed to convert the reciprocating motion of the beam into a continued circular motion by means of the crank. He was anticipated in taking out a patent (unfairly it has been said), and invented the *sun and planet wheel* as a substitute.

were those which adapted the power from the unceasing strokes of a piston to the very objects M. ARAGO mentions—that is, generally speaking, to procuring a smooth, equable, rotary motion, capable of being easily and quickly increased or diminished in power, without any violent shock or derangement of the parts—and that this had long been a desideratum in practical mechanics. But the passage requires comment, as, I repeat, although I do not suppose that M. ARAGO intended it, the effect is disparaging towards some of the happiest efforts of WATT's genius.

Again, M. ARAGO states, p. 90—

"I do not know if HOMER and ARISTOTLE, if DESCARTES and NEWTON, would appear in the eyes of these new ARISTARCUSES, worthy of a simple bust; but assuredly they would refuse even a modest medal to our PAPINS and VAUCAUSONS, our WATTS and ARKWRIGHTS, and to other mechanists, unknown, perhaps, in a certain circle, but whose renown will go on augmenting from age to age with the progress of knowledge."

In p. 103, we find—

"This, gentlemen, is a very abridged sketch of the benefits bequeathed to the world, by the machine of which PAPIN supplied the germ in his writings, and which, after so many ingenious exertions, WATT carried to such admirable perfection."

And in the same page—

"We have long been in the habit of talking of the age of AUGUSTUS, and of the age of LOUIS XIV. Eminent individuals amongst us have likewise held, that we might with propriety speak of the age of VOLTAIRE, of ROUSSEAU, and of MONTESQUIEU. I do not hesitate to declare my conviction, that, when the immense services already rendered by the steam-engine shall be added to all the marvels it holds out to promise, a grateful population will then familiarly talk of the ages of PAPIN and of WATT."

The associating PAPIN and WATT together, as in the three preceding extracts, is almost too absurd in reference to WATT, to require more than pointing it out.

Why, in this enumeration of the landmarks of an era, is NEWCOMEN forgotten? And why is PAPIN so elevated, who simply combined two ideas previously in existence, and could not go beyond the bare idea; who was never able to work out his idea, and finally abandoned it to seek for other modes of attaining the desired end. Why is NEWCOMEN omitted, who perceived the capabilities of this scheme at the very time when it was abandoned by its parent, and generally condemned; who, by an elaborate series of experiments, and many ingenious contrivances and applications, brought it to a working state and introduced it into practice?

And is it not lowering WATT to place him on the same level with *any* of his predecessors, more particularly with one who did so little as PAPIN? WATT not only suggested a new and beautiful principle (causing the steam to rush of itself into an adjoining vessel), fully equal in novelty and in genius to PAPIN's bare proposal to combine the schemes already known; but gave practical effect to that principle, and extended immensely its range of application by a number of the most ingenious, beautiful, and novel mechanical contrivances. Be sides the numerous mechanical inventions, including the double acting engine, WATT developed *new properties* of steam, not only important in their appilcations, but shewing high inventive genius in their discovery—namely Nos. 4, 5, 6, and 7, in page 19.

—PAPIN invented nothing—developed no new idea. WATT shewed extraordinary fertility of resources in meeting many difficulties which the more complex structure and more extended applications of the engine offered to him.—PAPIN was unable to go beyond the first crude notion which struck him. WATT brought his machine into such a state, not only inventing new principles, but extending and adding so much to it, that seventy years' experience has suggested no material alterations.—PAPIN merely proposed the sufficiently obvious combination of two principles already before him, left the proposed machine in a totally unfit state for practice, and with so many defects and difficulties, that it was not likely to suggest much to others, more particularly as it was transmitted with its author's condemnation.

Such being the comparative merits and services of PAPIN and WATT, we leave the reader to judge whether or not we err, in pronouncing it a monstrous exaggeration, to associate PAPIN with WATT as if on an equal footing—whether or not the doing so, more particularly when the former is described as furnishing the germ of an engine which the latter carried to perfection, is not a gross injustice to WATT, and has the effect of robbing him of half of his glory.

To speak of "the age of PAPIN" is truly extravagant. Indeed it is not likely that ages will be characterised by the leading inventors—by those who distinguished themselves for mechanical genius. Eras will always be marked, as they hitherto have been, by the names of those who have given a

stimulus to mind—those who by their writings or their deeds—such as statesmen and political authors, poets, moral writers—tend to advance mankind as intelligent beings, to work out a moral revolution. But since M. ARAGO estimates mechanical services so highly, may we suggest to him that there was an inventor called SAVERY, who produced the first working substitute for horse-power or water-power in raising water; and that there were SEVENTY YEARS, which, if an era is to be marked by the name of him who increases the means of procuring *power*, most persons would term "the age of NEWCOMEN."

M. ARAGO takes much pains to show the wonderful effects which have flowed from WATT's inventions. He asked more than a hundred people of all classes and all parties in Britain, "What is your opinion of the influence which WATT exercised upon the wealth, the power, and the prosperity of England," and that they all united in placing the services of our associate above all comparison. M. ARAGO need not have given himself any trouble on this point, as no one ever disputed what is perfectly self-evident, that the improvement of the engine for raising water, and the invention of the engine for propelling machinery, were followed by most important results. But I do not think the eulogist of WATT should insist too much upon this point, or should occupy much of his pages with praise awarded because great results have flowed from his inventions, while the invention itself is somewhat briefly sketched. It is apt to distract our attention from the true source of admiration for WATT, the genius displayed in his inventions. The mariners'

compass, and gunpowder, produced, in their day, nearly as important results as WATT's inventions; but we do not therefore regard their discoverers as men of genius. Printing produced more important consequences than any other invention ever did, or is likely to do—but we do not therefore consider GUTENBERG as a genius of a higher order than WATT. Far from it; every person knows that any one of WATT's inventions displayed more creative power than the discovery of the art of printing. I cannot but think therefore, that we should have been impressed by M. ARAGO with a higher opinion of WATT's genius, if a somewhat less portion of the Eloge had been devoted to enforcing by striking illustrations, and an imposing array of figures, and the opinions of men who were no judges of WATT's inventions, the very obvious truth that a cheap and effective power was of immense value to society—and if the number of beautiful inventions by which that end was attained, had been more minutely explained, and more warmly eulogized. It is upon these that the true admirer of WATT will dwell with pleasure and enthusiasm; and I regret to find that in M. ARAGO's Eloge, their ingenuity, novelty, and beauty, are not brought out and expatiated upon with that fulness, admiration, and warm praise that was to be expected, and that is displayed in other places where it is less called for.*

* I state that as my own impression. For proof, I must refer to the Eloge itself; and, not producing any evidence on this point, which I could not do without quoting the whole, the cautious reader will defer forming a judgment on it, till he peruses the Eloge.

In conclusion, then, it appears,

1. That M. Arago has omitted from the list of contributors to the application of steam as a power, Garay, Mathesius, Worcester, and Morland, all of whom, in some degree, forwarded the progress of this great invention.

2. That far too high a value is set on the bomb-bursting experiment of the Frenchman Rivault.

3. That Porta, the Neapolitan, who first showed clearly the force of confined steam, who showed its power exerted in raising water, the object which first led to the useful application of steam, who gave a drawing of a small apparatus, and a description, to which nothing was wanting but the idea of use on the large scale, is unfairly dealt with in being excluded altogether from the catalogue of contributors to this gradually progressing invention.

4. That by keeping Porta out of view, a much higher idea must be entertained of the merits of De Caus than he is entitled to; standing forth as the inventor of a mode of raising water, while he only suggested the use of a project already in existence.

5. That the value of the hint of De Caus, the Frenchman, is highly exaggerated; and that to speak of him as describing a machine fit for any service, is to detract from the merits of Savery, the Englishman, who invented, described, and first constructed a steam-engine on that plan.

6. That the merits of Savery, whose engine included an important point, (separate boiler,) wanting to render De Caus' scheme of any use, and another principle, differing altogether, (vacuum by steam, and suction pipe,) are slurred over, and depreciated, his machine not fairly explained, and that he is erroneously represented as merely constructing the engines described by Worcester and De Caus.

7. That the services of Papin are greatly over-rated by